Experiences with Direct Reading Instruments for Exposure Assessment

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Background

- Method: Review how direct reading instruments have impacted study findings.
- Objective: Provoke discussion.
- Used mostly direct reading instruments for aerosols.

Instruments used during field trials.

- Aerosol photometer
- Optical particle counter
- Condensation particle counter
- Surface area monitor
- Photo-ionization detector
- Flame ionization detector.

Optical aerosol Instruments.

- Text note that response varies with :
  - Optical properties
  - Size
  - Shape
  - Wave length of radiation
- Response not directly related to mass concentration
- Quick response time

Aerosol Photometer Response Varies With Aerosol

Aerosol Type	Response Factor C_{pDR}/C_{filter}
Environmental tobacco smoke	6.94 ± 0.88
Rural background aerosol	1.92 ± 0.73
Diesel particulate matter	0.62 ± 0.16

Source: Benton-Vitz John Volckens (2008): Evaluation of the pDR-1200 Real-Time Aerosol Monitor . Journal of Occupational and Environmental Hygiene, 5: 353–359

Heitbrink's perspective and biases.

- Instruments are used to understand how exposures occur.
  - -Trade off quickness for accuracy
- Study how concentrations vary with time
  - - Determine how process affects exposure
  - - Identify tasks affecting exposure
  - - Need good time resolution
- Study how concentration varies with location
  - - Identify hot spots
  - - Determine where controls are needed.

Review three recent studies involving:

- Wet abrasive blasting;
- Dust control for mortar removal; and,
- Concentration mapping in an engine plant.

Looking Across time – field evaluation of control measures for mortar removal

Work Practices Affected Exposure

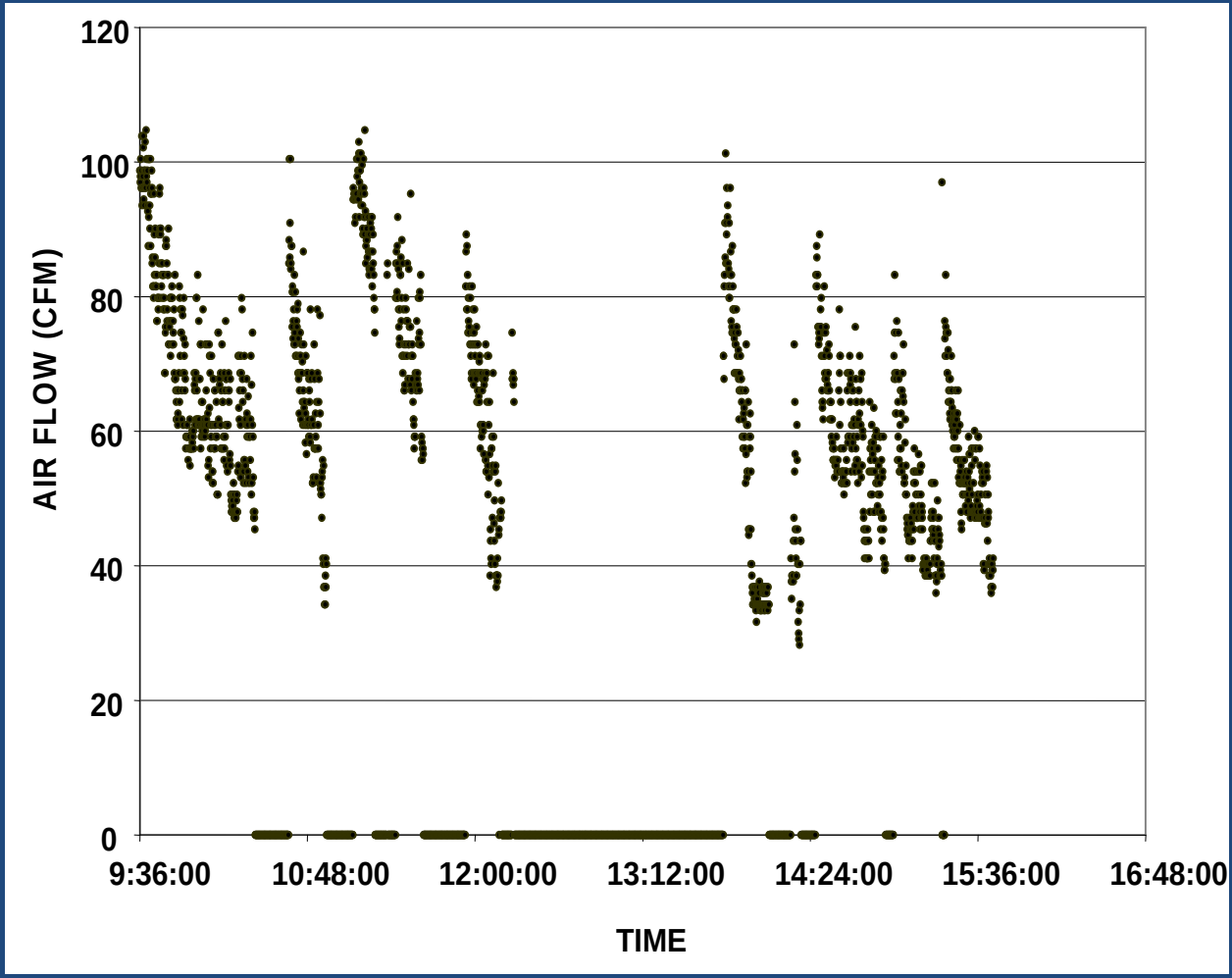
- Videotape worker grinding mortar and simultaneously log digitally:
  - Dust exposure with a real-time aerosol photometer.
  - Vacuum air flow with a data logging pressure transducer.
- Overlay exposure and vacuum flow rates onto video and observe work practices with resultant exposure and flow.

Video Exposure Monitoring illustrates the complexity of dust control during mortar removal

The horizontal joint under the exhaust take-off is missing. The mortar dust escapes the shroud and causes the workers dust exposure increase dramatically. Dust exposure is 20 mg/m³ (in purple on left) at 101 cfm (in red on right).

Routine horizontal cut. The mortar debris is being efficiently captured at a flow rate of 52 cfm and the worker's dust exposure is 0.15 mg/m³.

Maintaining air flow is an issue! Concentrations and these task-related independent variables may be cyclic as work can be repetitive. What does this mean for data analysis?



Note: air flow obtained From static pressure measured At inlet to vacuum cleaner motor. Fan curve used to convert static pressures to air flow.

Sometimes the dust plume does not go into the workers breathing zone!

Video Exposure Monitoring Results

- Elevated dust exposures occur during:
  - Grinding blade entry/exit.
  - Repeat cut in same joint.
  - Very poor mortar conditions.
  - Confined space areas.
- Overtime, as vacuum bags loaded, flow rates decreased and dust exposures increased.
- Impacted practical guidance on dust control.

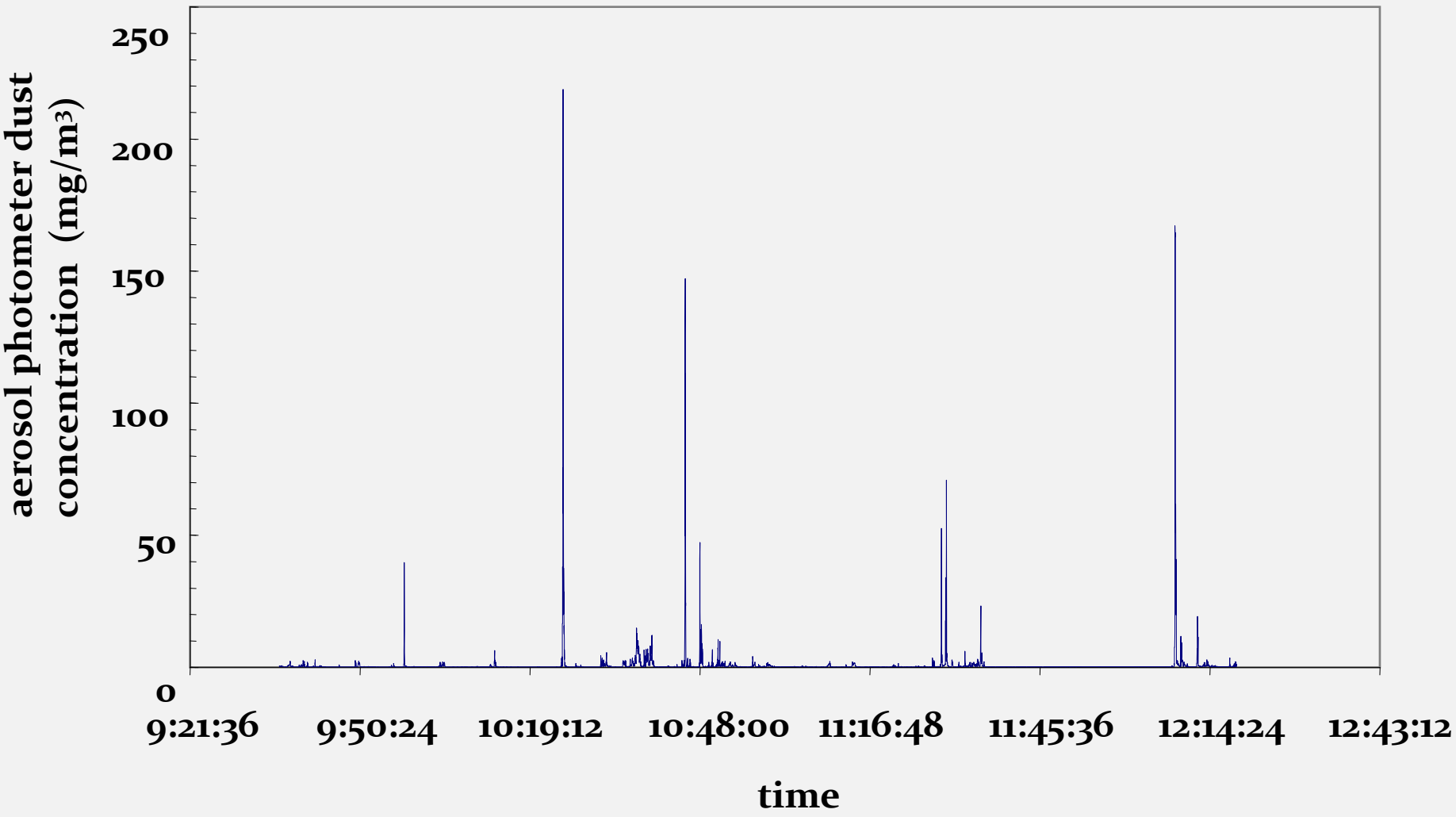
Studying planning and data analysis issues:

- Evaluate whether the differences in concentrations with task are really different?
  - Autocorrelation and statistical analysis?
  - Nyquist's sampling criteria?
- Dust plume does not necessarily flow toward the worker and instrument!
- How can one integrate process related variables with exposure measurements?
  - May be needed to develop control strategy.

Looking across time-
Wet abrasive blasting

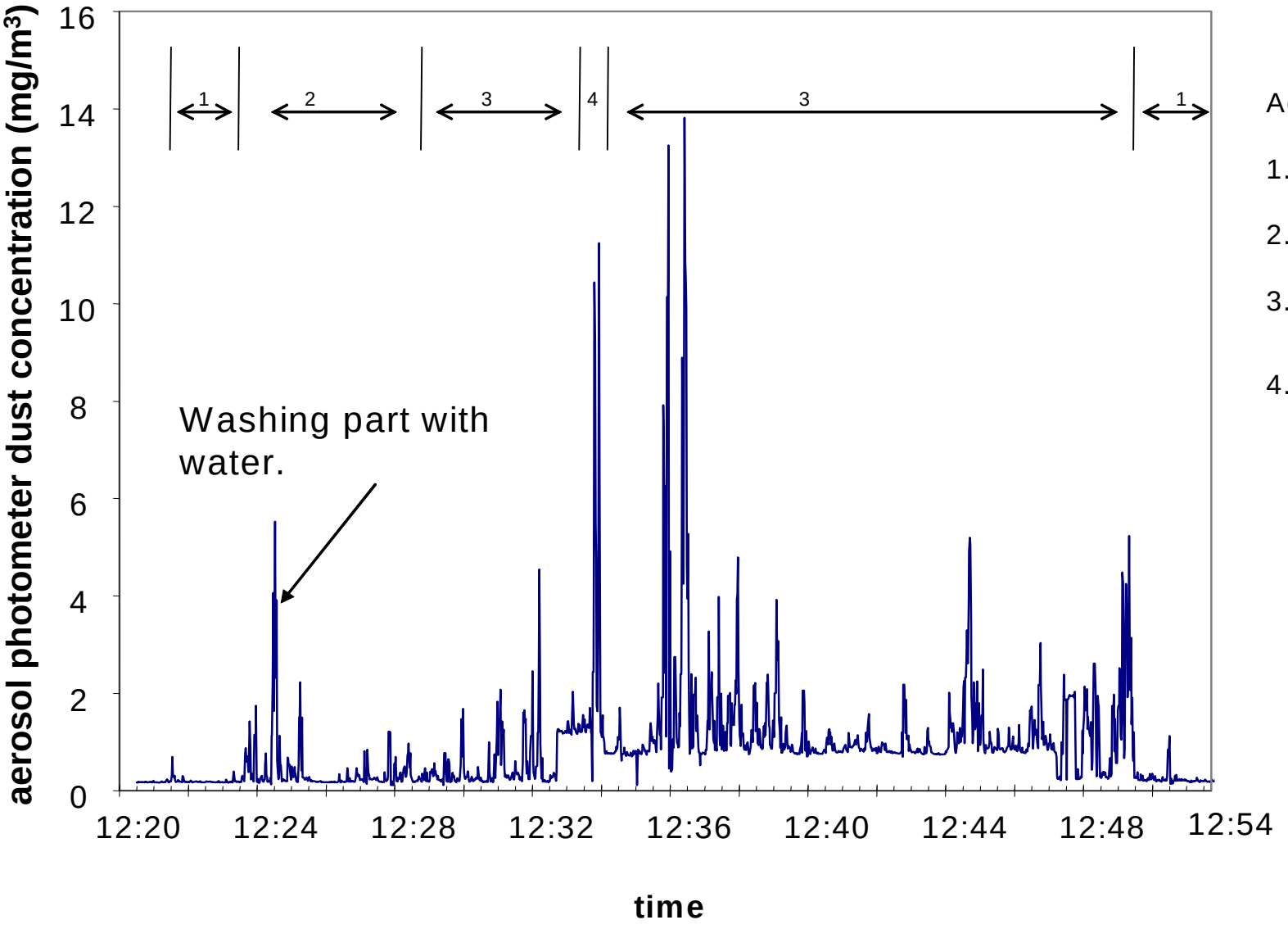

Filling abrasive blasting pot creates dust

AEROSOL PHOTOMETER MEASUREMENTS IN DUST PLUME FROM POT FILLING.



Wet abrasive blasting can be messy!

Non-specific responses are problematical! Are peak concentrations water, dust or crystalline silica?



Activity number

1. Filling pot with sand
2. Rinsing part with water
3. Wet abrasive blasting
4. Moving hose

Wet Abrasive Blasting: Discussion

- Bin Filling is not big issue, the worker avoids dust plume.
- Is the aerosol photometer response caused by water mist or by aerosol? In preparing report, I ignored this result.
- Understanding instrument response is important so that one does not over react to results.

Looking across space-
Concentration Mapping

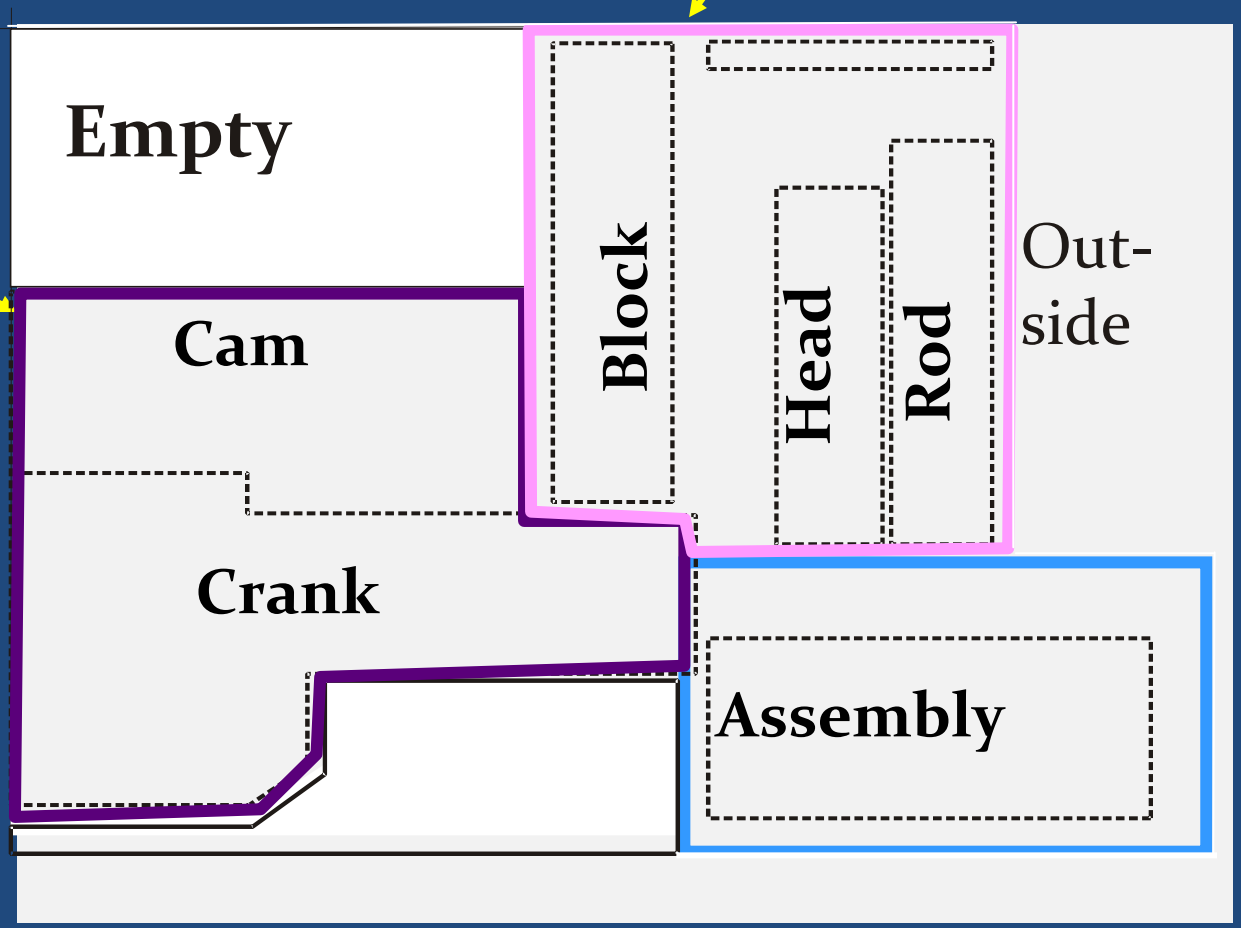
Mapping Procedures

- Used condensation particle counter and optical particle counter to obtain concentrations.
- Sample one-minute at each position
  - Coarse grid (60 points)
  - Fine grid (200 points)
- Create aerosol maps

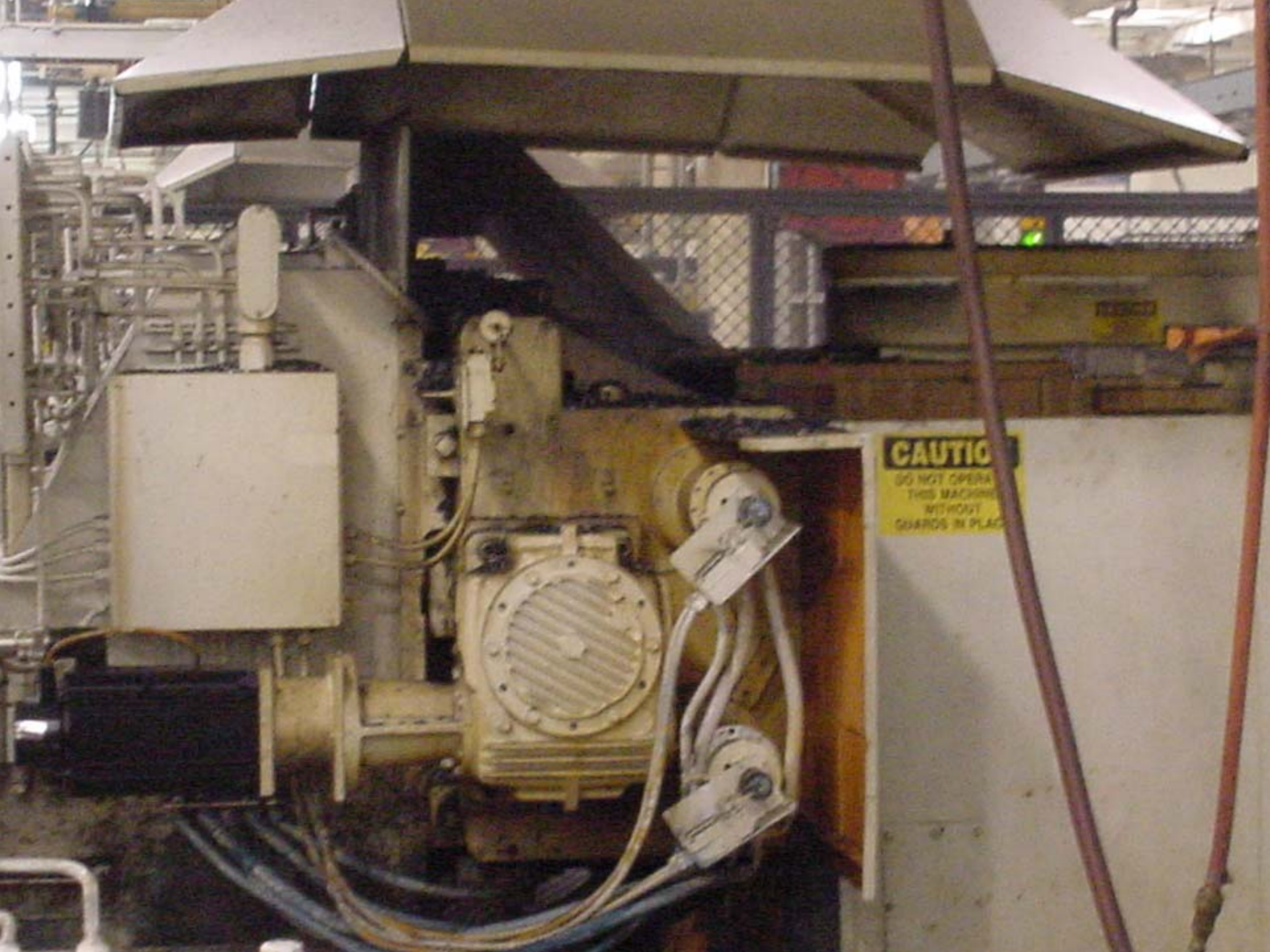
Engine Machining and Assembly Center
Produced 1000 engines per day

New Enclosures;
Gas Heat

Retrofitted
Enclosures;
Steam Heat



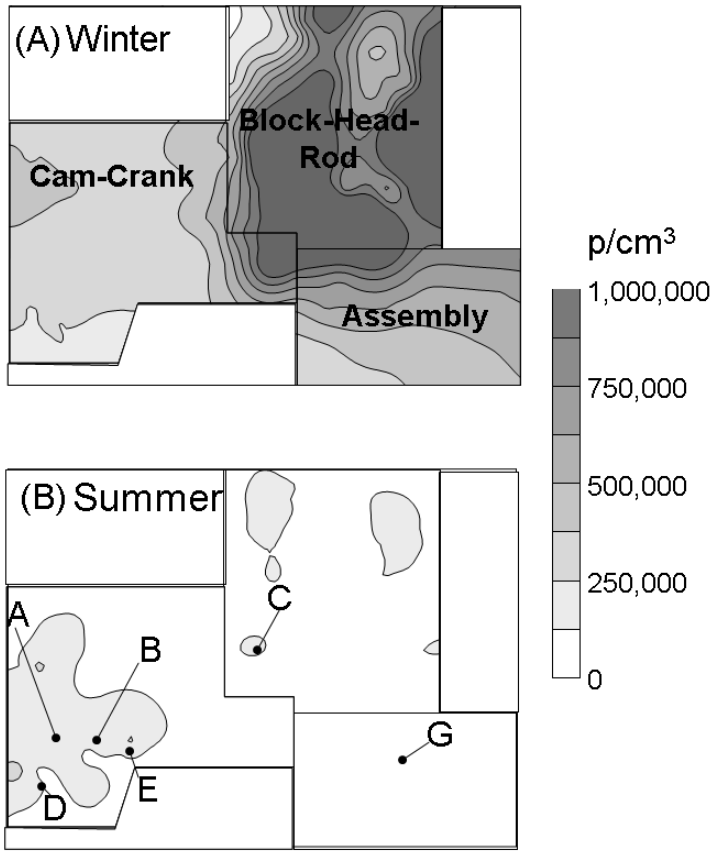
870 ft x 1,200


CAUTIO

Block-Head-Rod Lines had nearly complete enclosure appeared to completely control the mist generated by machining operations.

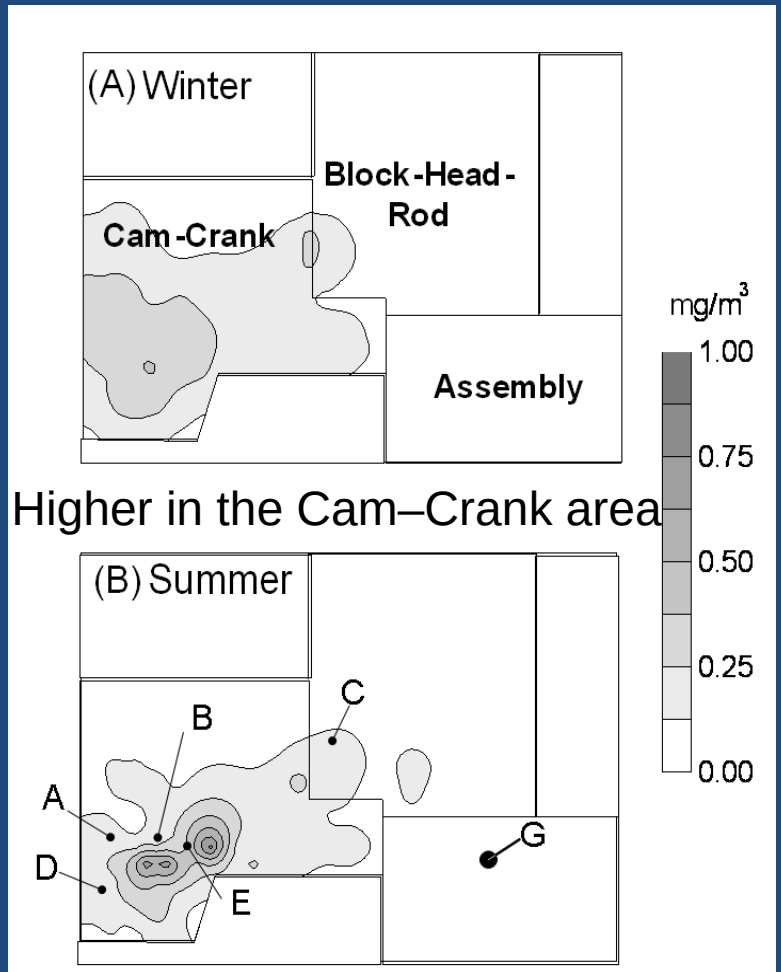
Different metrics - different picture of exposures.

A. Number concentration



Varied significantly with season

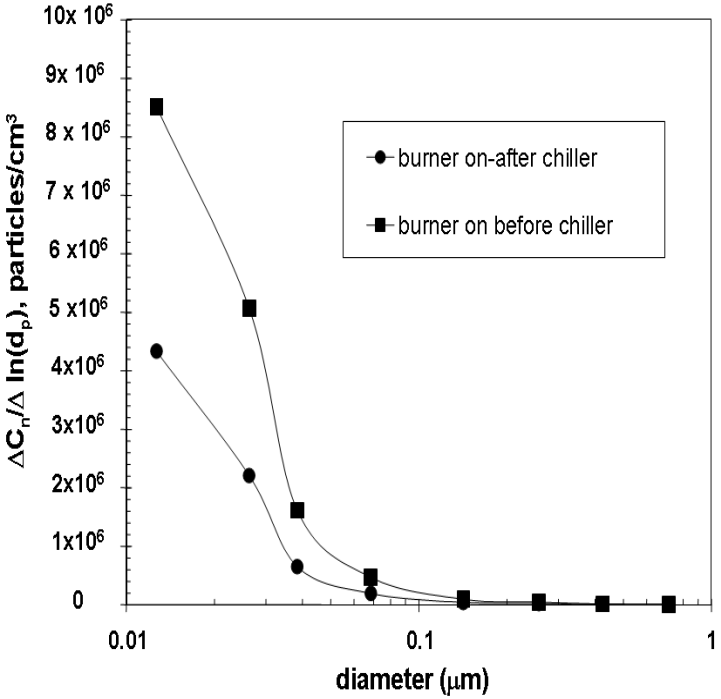
B. Mass concentration

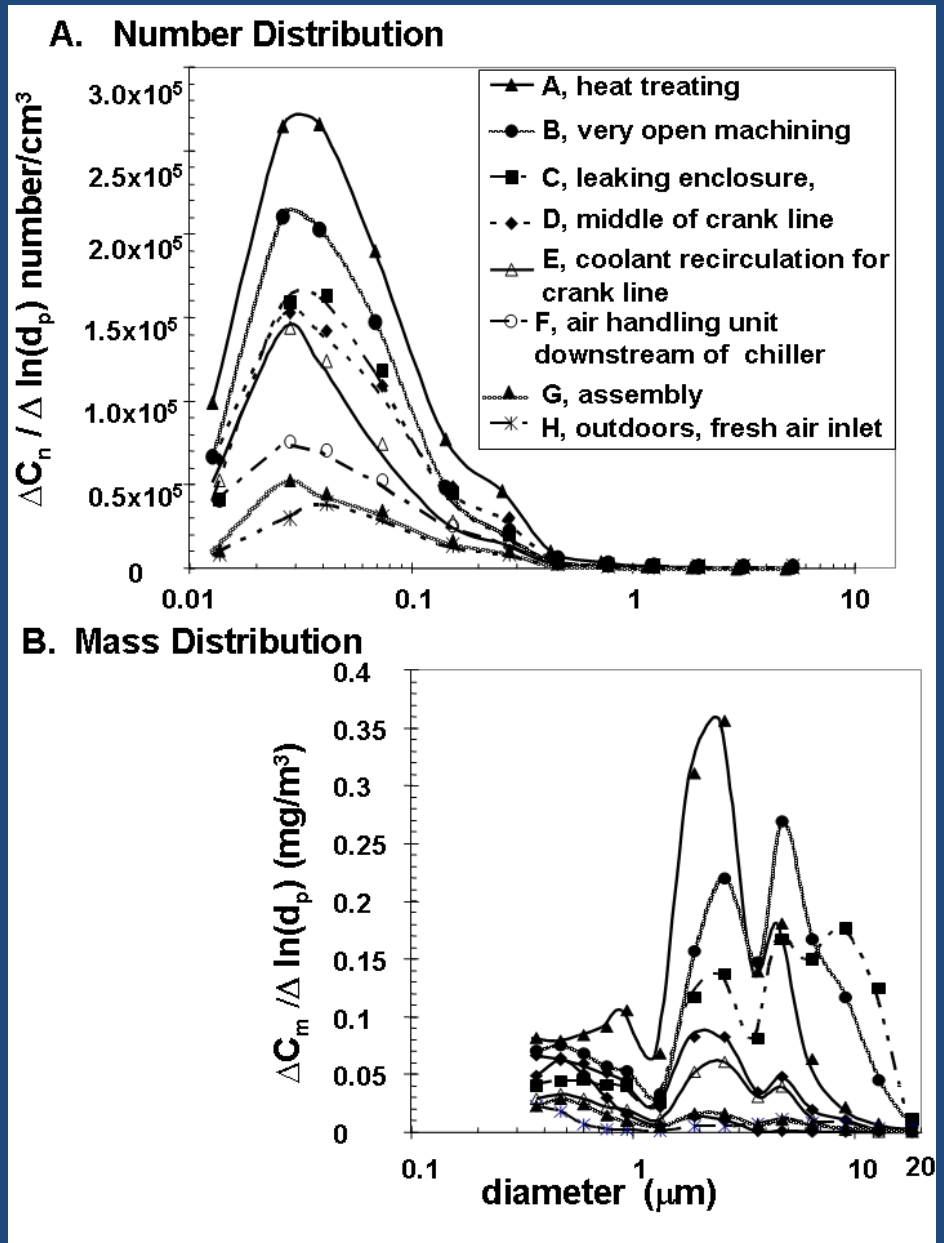


Higher in the Cam–Crank area

Varied significantly with location

Size distribution information needed to interpret results.





Concentration Mapping: Data analysis/Data interpolation issues

- Spatial and temporal autocorrelation.
- Artifact generation with ELPI.
- Size distribution information needed to interpret data.

Advantages of optical instruments (non specific)

- Optical instruments are fast enough to follow industrial processes.
- Reasonably rugged.
- Generally, relative concentration measurements have not been problematical.

  If aerosol varies, instrument response could lead into badly interpreted data.
- Can be used to devise control/interventions to reduce exposures.

Limitations of current optical instruments

- The response of the optical instruments varies with particle size and aerosol optical properties.
- Not useful for studying the association between health outcome and exposure.
- Personal TEOM has some commercial availability.

  Is response time is too slow for some studies?

  More related to mass than optical instruments

Future Direction Thoughts

- Develop applications for the use instruments as a problem solving tool:
  - Data analysis and study design procedures.
  - Problem solution-Intervention development.
  - Understand how to apply instrumentation
- Conduct research to understand the behavior of direct reading instruments.
  - Instruments will involve trade-offs between accuracy, response time, cost, and size.
  - Artifacts need to be understood.

Future Directions (Continued)

- Improve relationship between direct reading instruments and actual exposure metrics.
  - Exposure limits are based upon long-term health effects.
  - Develop application as a screening tool.
- Different instruments for different applications